

F-117 vs S-125M Neva, stealth, myths and urban legends

Concerning on low observable capability (“stealth”) it is worth to mention the only occasion (so far) where a stealth aircraft was downed. It happened during the 3rd night of the Operation of Allied Force in 1999 when an F-117 was downed by the Serbian air defense.

Many people and articles made false claims about stealth capability and features of old Soviet radars and SAM systems. Some people stated the stealth simply does not work at all against certain types of radars. Some papers and websites went much further and forecasted the fall of stealth designs and extinction of stealth airplanes. These statements are laughable, especially considering the two decades of development since 1999.

- “Invisible” airplane for radars do not exist. Only the media (and maybe the military propaganda) called them without any specific knowledge in the topic. This has to be obvious considering after knowing and understanding the principle of radar cross section (RCS). The stealth airframe design does not make invisible the airplane. It makes “only” much harder to detect from certain angles for radars. Stealth capability provides huge tactical advantages for the pilots comparing to conventional airplanes. It reduces the time and possible counteractions of the opponents in medium-long range engagements.
- Undefeatable combat airplane does not exist as well as does not exists unsinkable ships. A stealth airplane is effective as long as is used properly. Of course, the stealth itself has its own limitations.

Therefore, looks very different the F-22 and F-35 than the F-117. The first two 5th generation fighters do not rely simply on being stealth. Regardless the F-117 was designed to be stealth the limitations of the conception were much harder in the mid/late ‘70s then for later designed fighters such as F-22 or F-35. Only plain surfaces could be used to design the airframe which can fly and stealth. Designing a supersonic fighter plane for air combat was not possible.

Making invisible an aircraft as we known today is impossible because in visible light spectrum currently is not possible to hide a fast moving object.

Another problem is the infra-red spectrum. Because of the engine and airframe, the temperature difference between and airplane and the atmosphere or the sky background which makes possible to detect the F-117 with infrared (IR) seekers. F-117 flew only at night the and it was painted to black to make at least impossible to detect the F-117 in visible spectra.

- Another disadvantage of the F-117 was its avionics. It did not have radar warning receiver (RWR) because it was not feasible to equip the airframe without sacrificing the stealth design. Only against pre-briefed targets was effective the Nighthawk. Against such target carefully could be planned the route to target for using the best way the aspect dependent stealth capability.
- The SAMs which was used during the Operation Desert Storm by Iraq were similar to Serbian units. From 1299¹ combat sorties not a single F-117 was downed while in first days of Desert Strom the IADS of Iraq was intact. How could this happen? One of the key elements is the crew. To use well any equipment a

¹ <https://www.af.mil/News/Art.aspx?igphoto=2001335477>

skilled crew is needed.² The Arabian Wars proved this requirement was a too high bar for many Arabian countries.³ The case of Serbia was different.

- F-117s attacked “hard” targets because its weapons and avionics. The Nighthawks used only GBU-27 laser guided bombs (after 2000 was integrated the GBU-31 JDAM bomb). F-117 could attack such targets which were impossible to destroy without precision guided munitions (PGM) such as bunkers, hardened shelters and other high value assets. These targets were strongly defended which meant generally higher threat level for the F-117. This factor should be considered for judging the loss rate of the F-117.

It is surprising but considering loss/sortie ratio the F-117 had worse statistics than some conventional jets during the Desert Strom in 1991. Considering both the Desert Storm and Allied Force following about 1300 sorties was lost the first and only F-117. It happened on the 3rd night of the Allied Force. Following the loss, the F-117 sorties above Serbia continued. Depending on sources 400-800 sorties were flown in total.⁴ Besides the one downed Nighthawk one more was damaged. Later the Nighthawk flew sorties above Afghanistan and Iraq. Even considering these the total sorties flown by F-117 was not more than 1800 in regions where SAM threat could be expected. Afghanistan did not have air defense, Iraq also had almost nothing in 2003.

During the Desert Storm the following type had these statistics:⁵

Type	Sorties	Loss	damage	loss rate	damage rate
F-16	13 087	3	4	4 362	3272
F-15E	2172	2	0	1 086	-
EF-111A	1105	1	0	1 105	-
F-4G	2683	1	0	2 683	-
A-10	8084	5	12	1 617	674
OA-10	660	2	0	330	-
F-111E	458	0	0	-	-
F-111F	2423	0	3	-	808
Tornado GR.1 (UK)	1644	7	0	235	-
Tornado GR.1 (ITA)	224	1	0	224*	-
Jaguar (UK+FR)	1771	0	4	-	443
F/A-18 (USN+USMC)	4449	3	7	1 483	636

Until January 24th RAF Tornados flew only 236 sorties in total, 199 were low level OCA (offensive counter air), strike missions with JP-233. During this period five Tornado was downed which means 47 sortie/loss rate but if we consider only OCA missions this means 40 sortie/loss rate.

We can see the type of targets, and the way as any airplane is used had very strong impact on losses. Some airplanes had much higher losses comparing to career loss ratio of the F-117 some had much less. During Desert Strom following the first week the Coalition’s air force switched to med-high level altitude flying. Because of the weak resistance of the air defense the luckier airplane types could achieve even 0 loss.

² An F-117 pilot said there is a big difference how is used a SAM by a conscripted not highly trained operation and operator close to an engineer.

³ <https://www.meforum.org/articles/other/why-arabs-lose-wars>

⁴ <https://www.f-117a.com/AFMissions.html>, <https://bit.ly/36ALqW1>

⁵ <https://media.defense.gov/2010/Sep/27/2001329816/-1/-1/0/AFD-100927-065.pdf>

Some sources initially claimed F-117 operated without stand-off jammer (SOJ) support and attack alone targets but this is not true, F-117s mostly got this support. Actually, the lack of SOJ support could be one of the main reasons of the success of Serbian air defense.

- After the Operation Allied Force many people thought the lost F-117 will bring the end of stealth designs even before they became widespread. Since 1999 USA, Russia, China and many other countries designed stealth fighters and stealth cruise missiles. The superpowers and other advanced western countries (UK, Benelux states, Japan, Australia South-Korea, etc.) equip their air forces at least partially with stealth fighters.
- Some people stated F-117 retired without replacement therefore it was a failure. Of course, this is not true. If the F-117 would have been a failed airplane it had not been kept in service for 9 more years after the Allied Force.

When the majority of the F-117 fleet was retired in 2007/08 – in fact, it did not retire just placed into long term storage⁶ – the initial operation capability of the F-35A was expected within only some years with such capabilities which never could be achieved with the F-117. In that time, it seemed unreasonable to spend more resources to keep in service the F-117 fleet. Only problem the IOC of F-35A happened far later than was planned. Even when F-35A entered service it meant not fully capable multirole fighter. It could be used only with restricted performance because of unfinished software.

Even after two decades the only combat loss of the F-117 on the Internet and elsewhere way too many times can be found urban legends and myths about the case. Regardless both the pilot (Dale Zelko) and the commander of the SAM battery (Zoltán Dani) many times talked about the case for the public and Serbian books also have been written about the case these legends do not want to die.

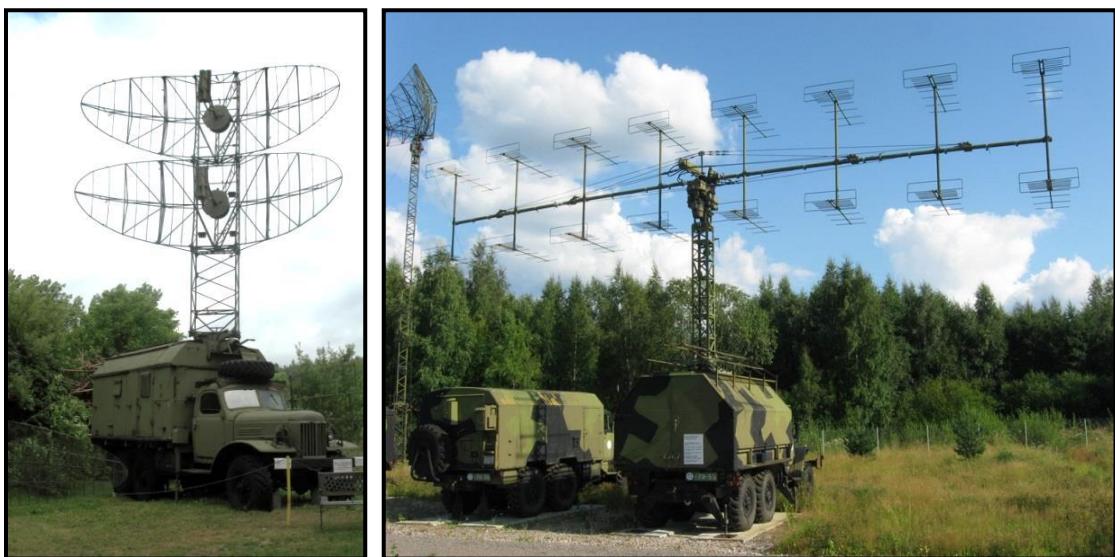
Let's start with the equipment which participated in the shot down. The success was achieved with an S-125M Neva (SA-3B Goa) system but the battery was not a standard S-125M battery because of its target acquisition radar.

Serbia had to phase out the S-75M Volkov SAMs because of the Dayton Agreement, but the treaty allowed keeping the long range target acquisition radars, these were the P-18 (Spoon Rest) radars. The P-18 operates on longer wavelength range (meter) comparing to the P-15 (Flat Face) which operates in dm wavelength range which is more suitable against stealth design.

The stealth design of F-117 was optimized against fire control radars which uses cm wavelength. The detection range of P-18 even against conventional aircraft is about twice as high (270 km vs 140 km) against an F-4 Phantom II size airplane what P-15 can provide. These combined factors made possible to detect farther with P-18 the Nighthawk than could be achieved P-15. The early detection with target acquisition is very crucial because of the time window to engage and guide a missile. The S-125M Neva is an early '60s era SAM which means it has almost no automatization. The time from first detection to the launch is high at least 30 seconds but, but in most cases even higher.

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<https://foxtrotalpha.jalopnik.com/why-is-the-retired-f-117-nighthawk-still-flying-1544383008>
<https://www.youtube.com/watch?v=BZBfOmZACNM>
<https://bit.ly/2RZpzSX>



On the left side above is the P-15 on right is the P-18 radar.

According to statement of Zoltan Dani he made little adjustments⁷ in the operational wavelength of the P-18 without permit from their superior officer. This was not so unique move in peacetime sometimes did operators in WPACT, but it was forbidden because it could jam the TV broadcast. The change was minimal the operation frequency was changed only with 6 MHz (normal operational range is about 150 MHz).⁸ It is hard to judge how big was the impact was the frequency change but the P-18 was able to detect the F-117 from 25 km range with 10 km (offset) distance parameter.

When Zoltan's battery turned on the P-18 detected more than one targets besides the F-117 in another direction what left the airspace of Belgrade. The closer target flew alone which may could indicate the type of target According to Zoltan's statement he had no idea about that was an F-117. It could be identified just after found the wreckage of the plane. The radar returns and target indication on the screens are not enough to identify the type of the airplane.

The crew had to work fast because of the parameters of the target. The F-117 flew with about 800 km/h (220 m/s) at 8 km altitude. As we can see in the engagement zones of the S-125M⁹ the F-117 flew outside from the minimal engagement zone. In case of partially tail engagement at 10 km distance was possible the guidance but at 6 km was not. After the launch it took time for the missile to reach the target at 8 km altitude. In the moment of hit considering the direction of F-117 the fire control radar looked backwards while the missile turned towards to the target. The commander decided to use three point guidance (TT) because of expected jamming which never happened. Because target did not perform any defensive turn regardless of the kinematics limitation of three point guidance the missile hit the target. Shooting down the F-117 was a remarkable success with a skilled crew but luck also was a very important factor:

⁷ Some sources suggest this was just deception, but he never changed the frequency because such small change is insignificant. In peacetime some Hungarian operator change the frequency when MiG-25s flew targets to Hungarian SAMs at very high speed because it made a bit larger the detection range. The successful training interception in peacetime was awarded with extra leave days.

⁸ <http://www.radartutorial.eu/19.kartei/11.ancient/karte049.en.html>

⁹ See in the chapter about the Neva system.

- Only about 60 seconds were available for successful engagement from first detection until the moment of the hit. For the success target had to be in a very narrow engagement zone.
- The availability of the P-18 radar from the retired S-75M Volkov system instead the P-15. Only a very few Neva battery used the P-18.
- The only S-125M battery which was detached from the SAM brigade and moved outside from SAM ring of Belgrade was Zoltan's unit. It could be any other unit and also was totally just luck that Zoltan's unit was which had the P-18 radar.
- The battery deployed to an old SA-75 Dvina SAM site; from the 1st day of the Allied Force the unit was there. The battery did not use any of the radars, nor the radio to keep hidden their position. They communicated with the HQ via telephone using telephone cable connection. It is quite strange that NATO did not check the possible deployment locations the empty old SAM sites.
- It is also just pure luck that that old Dvina SAM site was in a good place to have the necessary engagement zone and change for guidance. The tracking range of the SNR-125 fire control radar (guidance station) was only about 15 km against the F-117. If the F-117 had flew just some km farther or closer or they turned on the P-18 just a bit later, they had no chance for success.
- It was no EA-6B Prowler stand-off jammer airplane nearby, therefore the P-18 radar was not jammed at all.
- It was also a luck that no one launched AGM-88.¹⁰ It has to be noticed Zoltan tried minimizing the length of emission. He very rarely allowed to use the SNR-125 longer than 21 seconds. Even just one time has been turned on the fire control radar following the emission or missile guidance they started to relocate and never turned on again on the same location the SNR-125 radar.
- Other Neva batteries also were able to track sometimes F-117s and launched missiles, but their positions were known, and they had only P-15. These factors prevented their success, but another F-117 was damaged and had to extract from the operation.
- Regardless some sources say, the bomb doors of F-117 was not open. The door has to be opened **only for second for bomb release**. The F-117 was not targeted anything at the moment. This is simply an urban legend, nothing else.

¹⁰ During the Operation Allied Force Zoltan's crew 23 AGM-88 HARM wreckage the total launched qty. could be even higher. With the LORO mode of the Neva the chance of detection of the launch of a HARM was close to 0 because the plane had to be tracked in the moment of launch comparing to wide beam mode of S-75M. See at the chapter about SA-2 missile family.



Zoltan Dani and his prey
(image is taken by Hpasp)

Maybe it sounds weird but the usage of P-18 was not limited by the battery commander. Sometimes it was used 12 hours without any interruption because the P-18 is cannot be targeted by the AGM-88 HARM because of its wavelength. Of course, were other electronic warfare assets but NATO was not able to locate well these radars somehow.

Even without anti-radiation missile it was possible to attack SAM radars outside the engagement zone of MANPAD and SHORADs with precision guided such as laser guided bombs. Therefore, the battery could not be totally safe even does not use its fire control radar.¹¹

It is not a coincidence that the 1L119 Nebo was designed as mobile as possible because against a very advanced opponent today remaining on the same station for long time does not guarantee the long term survivability.

In short, the shot down was achieved by a very skilled crew with hard work in combination with luck, but it had zero impact on the outcome of the Operation Allied Force (OAF). Only one more fixed manned airplane was downed an F-16C which also carried out by Zoltan's unit. But the price was quite high. Serbia lost about 1/3rd of all S-125M Neva and about 40% of 2K12 Kub-M3 batteries during the OAF. The best what Serbian air defense achieved that on the last day of OAF as strong SEAD escort was need as on the 1st day of the operation because even at last day SAM resistance was expected. Hundreds of AGM-88 missile were used to inflict such a loss.

Also, did not happen what many people forecasted. This incident had zero impact on developing stealth aircraft. But the OAF highlighted many issues, the USA realized the weakness of its SEAD & DED capability. The SEAD more or less worked but destroying SAM was much harder against a skilled opponent. Considering double digit SAMs (SA-10/20, SA-12, SA-15, SA-11/17) became evident that a new ARM and other EW assets were required dealing with the new threats. The latest AGM-88E HARM (AGM-88E AARGM) variant got combined GPS/INS (Global Position/Inertial), anti-radiation homing, terminal millimeter wave (MMW), multi-spectral guidance which makes much harder to survive a launch by simply turning of the fire control radar of a SAM.¹²

Other EW assets were also upgraded. Today is simply unimaginable that against USA anybody emits 12-24 hours with a powerful radar without getting "serious attention". Even such radical idea was considered that a special version of the BGM-109 get similar combined warhead as AGM-88E. This special cruise missile could patrol for 1-2 hours waiting the right moment to attack moreover. It was planned this variant the reusability with return capability. This conception eventually was cancelled but it showed how serious the threat of double digit SAMs.

Imagining in any future conflict that S-125M Neva or similar S-75M Volkov will massacre stealth airplanes with help of P-18 is simply nonsense. Their reaction time, mobility, effective range and all of their parameters

¹¹ <https://www.youtube.com/watch?v=ZJOWHdMVMay>

<https://www.youtube.com/watch?v=73-4wy7f5Lk>

¹² <https://www.naval-technology.com/projects/agm-88e-advanced-anti-radiation-guided-missile-aargm/>
<https://bit.ly/2Oq1aEW>

make them simply outdated. While new stealth fighters such as F-35 are far beyond the capabilities of the F-117. The Nighthawk was designed in the era when of these old systems meant the main threat while the F-35 is designed against the double digit SAM threats.

On 5th generation stealth fighters RWR is now available, moreover on F-35 DAS acts as a MAWS. The DAS can be combined with the much faster data link of the JSF. Besides these the maneuvering capability of the F-35 and the F-22 is totally different. The successful usage of old Cold War radar guided SAMs against these airplanes is so small even calling it theoretical is an over statement.

In fact, even the F-117 could outmaneuver the missile of the S-125M Neva because it is capable to perform 5G turn. Despite its looking F-117 is at least as maneuverable as A-6 Intruder was.¹³ In short one swallow doesn't make a summer especially if the swallow is very old...

Zoltan's unit also reported shooting down a B-2 but the claim never was confirmed with any evidence. The claim it seems impossible because of the flight level of B-2 which is about 12-15 km. Considering both radars of the S-125M (even with P-18) the B-2 simply flew outside of the possible engagement zone of the Neva. The P-18 may could track for a very short time the B-2 but considering random distances and the altitude of the target SNR-125 did not have any chance to track the B-2 enough soon to be able to launch and guide a missile.

¹³ F-117 performed demonstration flight before an incident occurred.
<https://youtu.be/8V6HQJluMyY?t=3m49s>
<https://www.youtube.com/watch?v=8Prl9botsrk>
<https://www.youtube.com/watch?v=X2wYvr20nAg>